CHAPTER 11

SUMMARY OF FINDINGS

In defining the Title Act Study in SB2030, the California Legislature specified a series of tasks that, together, would lead to recommendations for change in licensing the state's engineers. These tasks included:

- Meeting with representatives of the engineering branches and other professional groups.
- Examining the types of services provided by different branches of engineering.
- Reviewing and analyzing educational requirements for the separate engineering disciplines.
- Identifying the amount of overlap between engineering disciplines.
- Reviewing alternative methods of regulation in other states and assessing the impact these regulations would have if adopted in California.
- Describing the manner in which local and state agencies utilize regulations and statutes to regulate engineering work.
- Recommend changes to existing laws regulating engineers after considering how these changes may affect the health, safety and welfare of the public.

ISR assembled as much information pursuant to these tasks as possible within the time available. Some of the information necessary to fully satisfy the legislative requests outlined above was either proprietary (e.g., job analyses performed by private firms for NCEES, insurance rates and claims data for different types of engineers), not publicly available (e.g., national and state pass rates for NCEES exams), or inadequately defined and administered (e.g., state data on complaints against engineers). The unavailability of good information on a profession with significant impact on the public health, safety and welfare limits accountability in the exercise of that profession. Lack of accountability itself threatens the public's health, safety and welfare.

Underlying these tasks were several overarching concerns. The first was the amount of overlap between engineering disciplines regulated in California. Overlap occurs in the coursework required for degrees in different branches of engineering, in the work that employed engineers perform (formally measured through NCEES sponsored job analyses), in the NCEES exams used in licensing engineers that are based on job analyses, and in state regulatory structures that either permit or disallow the performance of work outside areas defined by educational preparation, the NCEES exams taken and/or subsequent work experience. The second overarching concern was whether there were sufficient distinctions between California's practice and title act disciplines to justify maintenance of its existing and unique regulatory structure. No other state allows unlicensed persons to practice any branch of engineering. Only California licenses use of a title, but permits unregulated practice of all but three engineering disciplines (civil, electrical and mechanical). The third concern was whether this regulatory structure adequately protects the public health, safety and welfare and whether a differential impact on public health, safety and welfare, if any, might be one justification for the practice/title distinction.

Significant findings from the analysis of educational requirements, job task profiles, examination outlines, pass rates, engineering employment and registration patterns, exemptions, complaints and insurance claims are summarized in the most appropriate section corresponding to the three overarching concerns.

Comparisons with ten other states and analysis of the treatment of engineering disciplines in California state and county codes (the California Code of Regulations (CCR) and those for Los Angeles, San Diego and San Francisco counties) and the Federal Code of Regulations (FCR) were used to create a context for understanding California's licensing system. Results from this analysis contribute to an understanding of the findings in each of the following sections.

Overlap (Commonalities Between Engineering Disciplines)

Overlapping Practice

Like law and medicine, engineering shares a body of knowledge that forms the basis for specializations covered in undergraduate and graduate programs or internships, residencies and informal apprenticeships. Medicine is at the more formalized end of a continuum defining specializations -- with internships and residencies built into the licensing process and board certifications in specialty areas. Although national exams are available for 17 engineering disciplines, the formal recognition of specialties within engineering varies by state. Most states have "generic" licensing, registering those who passed the Fundamentals of Engineering and at least one specialty exam as "Professional Engineers." In these states, professional engineers may practice any type of engineering, as long as they are competent through education or experience. This self-certified competence is only questioned after errors have occurred and a professional engineer is required to demonstrate an appropriate level of competency. "Discipline-based" licensing is used primarily in 16 smaller and more rural states and territories that recognize between six (Rhode Island) and 46 (Massachusetts) engineering specialties. These include: Hawaii, Alaska, Arizona, Nevada, Wyoming, Guam and the Mariana Islands. California and Massachusetts are the only large states to use "discipline-based" licensing with California recognizing 15 specialties. Most of these states define the specialty in terms of the subject matter of the comparable NCEES exam.

Generic licensing states do not attempt to regulate who does what in engineering except through the complaint and enforcement process. Discipline-based licensing states vary in the degree to which they regulate overlapping practice between disciplines -- work that is "incidental" or "supplemental" to the "normal" work of a specific type of engineer. Rhode Island allows no overlapping practice even though it provides no discipline definitions. Massachusetts, which also lacks discipline definitions, allows engineers to work outside their specialty with Board approval. Guam is the only jurisdiction besides California that restricts the *direction* of overlapping practice for some disciplines.

Allowable one-directional overlap by the practice act disciplines into title act areas, by civil engineers into mechanical and electrical, and prohibition of the reverse, is unique to California. With the exception of civil engineering, the purview of California's recognized disciplines is defined in Rules of the Board for Professional Engineers and Land Surveyors. In contrast, civil engineering is thoroughly defined, and mechanical and electrical engineering identified as other practice disciplines, in the Professional Engineers Act. These definitions specifically restrict the title act disciplines from practicing civil, electrical or mechanical engineering -- and the latter two from engaging in civil engineering -- while permitting the practice act disciplines to engage in any engineering activities as long as they are "incidental" or "supplementary" to work in their branch of engineering. Thus, a hierarchy is established among the practice act disciplines and between the practice and title act disciplines that is reflected in placement in the Business and Professions Code vs. Board Rules, in allowable one-directional overlap, and in a complaint process that primarily protects the practice act disciplines.

Commonalities in Educational Requirements

All engineers share a core of non-general education support units in physics, chemistry and math. At the seven selected California universities, these support units make up between a quarter (28%) and more than a half (55%) of all non-general education units required for an engineering degree. An engineering degree at Berkeley, Stanford and UCLA includes more units in these basic subjects than the CSU campuses and USC. Physics, chemistry and math make up between 40% and 55% of non-general education units required for the degree at Berkeley, Stanford and UCLA, between 28% and 35% at the CSU campuses, and 37% at USC.

Industrial and manufacturing engineering have the highest percentage of overlapping engineering and related support units. These disciplines share two-thirds (68%) of all non-general education courses (ranging between 64% and 71% at the three schools offering both degrees) and well over half (57%) of all engineering courses (ranging between 55% and 59%). Manufacturing and mechanical engineering are ranked second in terms of shared engineering units and third in terms of all engineering and support units, with 51% of all non-general education units in common and 38% of all engineering units in common.

Also ranking high in the proportion of shared engineering and all non-general education units is metallurgical with both mechanical and chemical engineering. Metallurgical shares 47% of all units with mechanical and 46% with chemical and 28% of engineering units with each of them.

Some disciplines share a much higher percentage of engineering units than they do in the support areas. Petroleum shares almost a third of its engineering units with mechanical and chemical -- the third and fourth highest of all discipline pairs -- but a relatively lower proportion of all units (41% and 37% respectively), ranking 13th and 21st among all discipline pairs. These disciplines differ more in their support areas. In contrast, nuclear and mechanical engineering are ranked second in the proportion of all units shared (52%), but 8th in the proportion of shared engineering units (27%).

NCEES Examination Outlines

Subject matter experts assisted ISR in comparing NCEES exam outlines for 21 discipline pairs: civil, mechanical and electrical with each other and six title act disciplines (chemical, control systems, fire protection, industrial, manufacturing and nuclear).

The first step in the analysis was to compute the percent of the title acts' exam content found on the separate modules of the practice act exams. Then the process was reversed and the percent of the practice acts' exam content found on the title act exams was computed. The second step was to rank the percent of overlap from each perspective, ranking all 148 combinations of breadth and depth modules and exams in terms of the average of the two. Finally, specific areas of overlap were described for combinations where an overlap of 15% or more existed.

There is much more similarity between practice and title acts disciplines than there is among practice act disciplines. Almost all (90%) of the 30 discipline pairs with the greatest amount of overlap are practice/title combinations. Conversely, most (80%) of the 30 discipline pairs with the least amount of overlap are practice/practice combinations. Twenty of these involve paired portions of the civil and electrical exams, with overlapping content of 1% or less. Electrical and mechanical are also very dissimilar.

On the other hand, civil and mechanical engineering are much more alike -- 14 of 24 comparisons between the two are in the upper half of the distribution. Overlap between the structural depth module and mechanical's breadth and thermal and fluids systems modules favor civil engineering. That is, material from the mechanical exams constitutes a higher percentage of the civil exams than the reverse. In seven other combinations, material from the civil exams constitutes a higher percentage of the mechanical modules, suggesting that, in these areas, mechanical engineers might be better prepared.

From the perspective of the title acts, most of the overlap with practice act discipline exams is on the breath and depth modules of the mechanical engineering exam. Roughly a third of the chemical exam is covered on the breadth and each of the depth modules of the mechanical engineering exam, especially the HVAC and refrigeration and the Thermal and Fluids Systems sections. Similarly, a third of the manufacturing exam is covered by the machine design depth module of the mechanical exam and a fourth of the control systems and fire protection exams by the HVAC and refrigeration depth module. Between 15% and 20% of the control systems, fire protection and manufacturing exams are found on the breadth and thermal and fluids systems depth modules.

From the perspective of civil engineering, most of the overlap with other discipline exams is in the environmental, structural and water resources depth modules. A fourth of the environmental depth module is found on the chemical exam and 15% on the industrial exam. The water resources depth module also overlaps with the chemical exam (15.24%). Mechanical engineering also shares the highest proportion of exam content with chemical engineering. Roughly a third of the mechanical breadth module and the HVAC/refrigeration and thermal and fluids systems depth modules are found on the chemical exam. A similar proportion of the machine design depth modules is found on the manufacturing exam. Most of electrical engineering's overlap with other discipline exams is with control systems, industrial and nuclear. The most notable overlap between practice act disciplines occurs between mechanical's machine design and the structural depth modules: 21% to 22% of each appears on the other exam.

The independence of exam content for two of the three pairs of practice act disciplines (between electrical and both civil and mechanical) strongly supports their separate disciplinary boundaries. But it also calls into question the one-directional allowable overlap of civil engineers into the other disciplines, particularly electrical engineering. Based on exam content, neither discipline should be engaged in the incidental practice of the other's responsibilities. There is a stronger case for bi-directional overlap between mechanical and civil engineering than there is for overlap in any direction between electrical and either civil or mechanical.

In addition, the extent of overlapping exam content between chemical and mechanical engineering argues against the current licensing system that permits one directional overlap by mechanical engineers into chemical engineering, prohibiting the reverse. In the cases of unbalanced overlap, a higher proportion of material from the chemical exam appears on the mechanical exam than the reverse -- suggesting that chemical engineers might be better prepared in these areas of the exam.

Distinctions between Practice and Title Act Disciplines

Introduction

The licensing of engineers in California began with civil engineers in 1929, prohibiting those not licensed from *practicing* civil engineering. In 1947, chemical, electrical, mechanical and petroleum engineering were licensed with *titl*e protection, prohibiting others from using the title of their discipline, but permitting anyone to practice it. The recognition of additional disciplines in the 1960s and 70s reflected either growth in scientific knowledge (nuclear engineering), the application of engineering principles to new areas (agricultural, fire protection, corrosion and traffic engineering), or the new 20th century focus on the social organization of production (control systems, manufacturing, industrial, quality and safety engineering). In the late 1960s, electrical and mechanical engineering were converted to practice protection while the disciplines of the 1970s were given title protection only. Structural and geotechnical engineering were defined as title authorities, an amalgam of practice and title protection. Licensed civil engineers may take additional exams to use the titles of structural or geotechnical engineer; but they may practice either type of engineering with their civil license.

It is a reasonable question whether there are clear and sufficient differences between the branches of engineering to justify differential treatment of the various disciplines. No other state allows unlicensed persons to practice any branch of engineering and most states of any size do not even distinguish the branches, offering licensing as a "Professional Engineer" to those completing a prescribed set of exams. When this question was posed at the Forum on Engineering Licensing 2002 and on DCA's website announcing the forum, participants and others offering public comment could not identify any criteria that distinguish practice and title disciplines other than the legal distinctions that have arisen with the historical development of engineering in this state.

ISR tested for differences between practice and title Act disciplines in the analysis of each data set examined in the course of the Title Act Study. Some differences may be less relevant to a decision to retain or eliminate the practice/title distinction; but they round out the picture of engineering education, employment and licensing and the nature of regulatory support and enforcement. Key differences are summarized below.

Education

- There are 74 accredited undergraduate programs supporting the practice act disciplines (52%) and 28 supporting six title act disciplines (20%) throughout the state. The six include agricultural, chemical, industrial, manufacturing, materials and nuclear engineering. Some disciplines lacking undergraduate degree programs are supported by graduate degrees at the selected schools. Graduate degrees are offered in two other title act disciplines, control systems and transportation engineering and in the two title authorities, structural and geotechnical engineering. Fire protection is taught out of state at a single location in the U.S.

- Options, specializations, or concentrations within majors are another way in which knowledge supporting a particular discipline is transmitted. Options within majors are less important for the practice act disciplines because these are strongly supported by degree programs (44% of options vs. 52% of degree programs). They are more important for the title act and unregulated disciplines: 27% of the options support title act disciplines, compared with 20% of the degree programs while 29% of the options support unregulated disciplines compared with 25% of degree programs. Options, emphases, concentrations or specializations, which are interchangeable terms, require between 11 and 18 units on average, although the range for individual programs varies from 6 to 24.

- Degrees in manufacturing, civil and mechanical engineering have the highest engineering course unit requirement (67, 66 and 65 units respectively) while chemical and petroleum engineering have the lowest (51.7 and 51.5 units). The dependence of chemical and petroleum engineering on basic chemistry and its inclusion in support units for all engineering degrees may contribute to the lower number of engineering units for degrees in these two fields. The seven schools require more units in the practice act disciplines than they do in the title act disciplines (64 vs. 57.7).

- Stanford requires the fewest units in engineering courses (43.9) and SLO the most (68.7). With the exception of Stanford and Berkeley (43.9 and 54.6 units on average), the schools' engineering course units vary between 61.6 (UCLA) and 68.7 (SLO and San Jose).

Pass Rates

Pass rates on NCEES examinations in California and the comparison states were obtained and described over a five-year period (1997 to 2001). In addition to the Fundamentals of Engineering (FE) exam, results were obtained for the following engineering disciplines: agricultural, chemical, civil and its five depth exams, control systems, electrical, fire protection, industrial manufacturing, mechanical and its three depth exams, metallurgical, nuclear and petroleum. Since the analysis focuses on relative differences between individual states, standard normal scores (z-scores) were computed to describe each state's distance from the weighted pass rate for the ten states combined. The higher the z-score the further a state's pass rate is from the rate for the combined states. A negative value indicates a lower than average pass rate while a positive value indicates a higher one.

- Some states are consistently above average in their pass rates on the FE exam, while others are consistently below. California's pass rate was at least nine standard deviations below the mean for ten comparison states in each of the five years, far and away the lowest among the comparison states.

- Pass rates on the FE exam are higher in "board-dominated" states and lower in "agency-dominated" ones.

- California and the other discipline-based licensing state with pass rate data are many standard deviations below the average pass rate on the FE exam while the generic licensing states are significantly above average.

- In California, the fundamentals and civil exams appear to work as screening devices for those seeking licensing. Although California's z-scores on the general civil exam are not as low as they are on the fundamentals exam, they are still significantly below average, varying between three and nine standard deviations below the mean for the ten states. A similar pattern is observed on the transportation depth exam that began in 2000 and to a lesser extent on the water resources depth exam that began in the same year. On all other civil depth exams -- and indeed, almost all other specialty exams -- California pass rates are very close to the average.

- The HVAC and refrigeration depth exam was one of the exceptions to the general observation that California pass rates on the specialty exams were in the normal range. On this exam, the pass rate was two standard deviations below the average for seven states. However, California was close to the average for the comparison states on the overall exam in mechanical engineering.

- The other major exception to California's generally average pass rates on the specialty exams was its performance on the electrical engineering exam. Pass rates on this exam were significantly below average in four of the five years surveyed.

Registration

Registration rates were computed by dividing the number of registered engineers by the number of employed engineers as estimated by the Occupation Employment Statistics (OES) survey, jointly sponsored by the U.S. Bureau of Labor Statistics (BLS) and State Employment Security Agencies (SESAs). In California, registration rates were computed by discipline even though they are unreliable for the less numerous (e.g., agricultural and chemical) and less specialized (e.g., civil) disciplines due to sampling and measurement problems.

Roughly half of employed engineers in California are registered (48%). For ten of the comparison states, registration rates varied between 44% (Texas) and 68% (New Jersey). Three states (New Jersey, North Carolina and Ohio) are grouped at the high end of this range, with registration rates between 64% and 68%. The remaining states are grouped at the low end of the range, between 44% (Texas) and 49% (Illinois). Rhode Island, with 60% of its engineers in government employment, is anomalous in having only 9.5% registered.

Agricultural, chemical and civil engineering are the three disciplines where the number registered is greater than the number estimated to be employed in the state (2.33, 1.54 and 1.04 respectively registered for every one employed). Nuclear and mechanical engineers have the next highest registration rates, with 88% and 60% respectively. Roughly half of all petroleum engineers in California are registered. Rates are lowest for materials (18%), electrical (13%) and industrial (4%).

Thus, there were no systematic differences between the practice and title act disciplines in registration rates. One practice discipline, civil engineering, had one of the highest rates, while another, electrical, had one of the lowest. Similarly, title act disciplines were found throughout the range.

Employment

Collectively, the three practice act disciplines account for 63.8% of all employed engineers in the nation, with industrial engineering the only other branch with double-digit percentages. In 2000, the OES survey found that, nationally, persons employed as electrical engineers outnumbered mechanical and civil by 1.7 to 1. Discipline-based states averaged 2.5 electrical engineers for every mechanical engineer and 2.4 for every civil engineer; comparable ratios in generic states are 1.6 for both mechanical and civil.

Discipline-based states have 42% more engineers than generic licensing states (519 vs. 365 per 100,000 population). They have almost twice as many electrical engineers per 100,000 population, 25 - 30% more mechanical and industrial engineers, but roughly the same number of civil engineers. California, however, has the highest rate of civil engineers (84 per 100,000) of any of the comparison states, which range between 42 and 78 per 100,000. The newer and more specialized branches of engineering (aerospace, biomedical, environmental) are also more common in the discipline-based states.

In 2000, engineers nationally were primarily employed by industrial corporations (69%), with 20% in engineering and architectural services and 11% in government employment. In contrast to the other disciplines, civil engineers were much more apt to be employed in engineering and architectural services than in government or private industry (50.6% vs. 29.4% and 20% respectively). California diverged significantly from the national pattern. Government employed over half of its civil engineers (56%) and only 37% were engaged in engineering and architectural services.

Job Classes

One way to understand the uses of licensing and the role of practice and title disciplines is to summarize registration and other requirements for the 194 job classes in state employment that specify an engineer with a four-year college degree in engineering. An online review found that 40% of 194 job classes required a licensed engineer. Among the jobs requiring licensing, 39% specified that the occupant must be a registered *civil engineer*, while another 25% required a registered *professional engineer*. Another 10% specified a registered *electrical engineer*. Other disciplines specifically mentioned were industrial, mechanical and structural.

The 194 job classes are grouped into 55 job class categories that relate more closely to specific engineering disciplines or the activity areas in which their skills are applied (e.g., automotive equipment standards, hazardous substances, hydroelectric power utility). In roughly half of the 55 job class categories, none of the job classes require a registered engineer (29 or 53%). In a fifth of the job categories (11 or 20%), all of the job classes require a registered engineer and in another fifth, over half do. The job categories where all job classes require a registered engineer account for 12% of all positions.

Job class categories requiring *100%* registered engineers include bridge, construction, drinking water, hydraulic, industrial, materials and research, mechanical and electrical, reclamation, registrar, seismic and subsidence engineering positions. Many of these positions involve practice act disciplines and their associated areas of expertise. Those requiring *no* registered engineers include air quality, air resources, automotive equipment standards, chemical testing, control, corrosion, energy and mineral resources, equipment, equipment and materials, flammability research test, geologist, hydroelectric power utility, mineral resources, mining, motor vehicle pollution control, petroleum, petroleum drilling, production and reservoir, petroleum and mining appraisal, pipeline safety, process safety, procurement, product, rehabilitation, reservoir, safety, telecommunications, and transportation civil engineering positions. Many of these positions involve title act or unregulated disciplines and their areas of expertise.

As of 12/31/01, there were 10,923 employees in the 194 job classes requiring an engineer. Almost three-fourths (72%) of these employees are in positions where registration is *not* required. Most of the employees in engineering job classes where registration *is* required are in positions requiring a civil license (19%). In short, most engineers employed by the State of

California do not have to be licensed. If they do, the license most often required is in civil engineering.

Codes

The Federal and California Code of Regulations (FCR and CCR) and three California county codes (Los Angeles, San Diego and San Francisco) were searched online for references to all of the engineering disciplines and combinations of the generic terms of registered or licensed professional engineer.

The most common term in the FCR is "registered professional engineer" (58% of all hits). Over three-fourths of all mentions of engineers in the FCR refer to professional engineers rather than specific disciplines. In the CCR, the two most common terms are "professional engineer" (30.4%), without any modifier, and "civil engineer" (29.5%). Only 8% of hits in the FCR identify civil engineers. There is much less emphasis on being registered or licensed in the California code (11.4% vs. 63% in the federal code).

Chemical, fire protection, petroleum and traffic engineers are the only title act disciplines mentioned in the state and county codes (3.4% and 3.6% respectively of all hits). Petroleum engineers are the only specialty that is mentioned more often in the FCR than in any of the state's codes.

Within California, the most frequently mentioned type of engineer in all four jurisdictions studied was the civil engineer. Geotechnical engineers were mentioned almost as frequently in Los Angeles and San Diego counties, while structural engineers were the second most commonly specified in San Francisco and at the state level. Generic titles appear more often in the CCR than in the county codes.

Most of the references to engineers are prescriptive statements (90% in the CCR and 84% in the county codes), requiring the involvement of an engineer in a specified activity.

Complaints

ISR analyzed twelve years (1990/91 through 2001/02) of complaint data collected by DCA and the BPELS to determine whether there were any consistent differences between practice and title act disciplines in the frequency and nature of complaints, their source, or the Board's response. A second purpose was to explore whether the differences, if any, had any implications for protection of public health, safety and welfare -- implications that are discussed in the next section of this summary chapter.

Most of the complaints are against either civil engineers (43%) or unlicensed individuals (45%). There are very few complaints against electrical and mechanical engineers (1 and 2% respectively). This distribution of complaints is not representative of the distribution of employed engineers in the state. Civil engineers constitute 15% of the state's engineering work force, electrical and mechanical engineers 30% and 11% respectively. Even if all of OES' "other engineers" category was assumed to be civil engineers (18% of the work force), civil engineers would be over-represented in the complaint process. Geotechnical, structural and traffic engineers are also significantly over-represented in complaints against registered engineers while the remaining title act disciplines are all under-represented.

Several explanations for the over-representation of civil engineers, including geotechnical and structural, have been put forward. The first is the varying employment locations of different branches of engineering. More civil engineers are employed in "engineering and architectural services" (37% in California) than electrical or mechanical engineers (6% and 19% respectively). Industrial corporations employ most electrical and mechanical engineers (82% and 76% compared with 7% of civil engineers). Almost all title act engineers are employed by industry. Although differential exposure to clients probably contributes to the over-representation of civil engineers in the complaint population, it is not the whole story.

Civil engineers are also over-represented, and electrical and mechanical engineers under-represented, in the claims population relative to their proportions in the engineering work force -- although more claims than complaints are filed against electrical and mechanical engineers. But, in the claims data, more mechanical and electrical than civil engineering firms are sued by clients (72% and 60% respectively vs. 51% for civil). Civil engineering firms are more likely to be sued by third parties (33% vs. 13% and 21% for mechanical and electrical engineers). Suits against corporations or government agencies for negligent or incompetent engineering practices are not in any available database. But the claims data suggest that injured third parties are an important source of claims and that factors other than exposure to clients affect what types of engineers are held accountable.

Another such factor suggested by the claims data is the type of projects engineering firms are engaged in. However, different project types engaged in by a single discipline can generate positive and negative claims/fee ratios and the same project type engaged in by multiple disciplines can generate different claims/fee ratios for the separate disciplines. For example, civil engineering firms had positive ratios for their work on roads and highways, generating fewer claims and claim dollars than they earned in fees, but a negative ratio for work on wastewater, sewage and water treatment systems. Civil engineering firms engaged in residential projects came out even -- generating similar proportions of claims and fees -- while, for electrical engineers, residential projects were much more damaging -- generating six times the number of claims as fees.

The weakness in the claims data is that there is no measure of the rate of claims relative to the number of firms covered; the only norming variable available for the number and dollar value of claims is the total fees generated by the firms sued. In addition, comparing the distribution of *firms* to the distribution of *employed engineers* is inexact.

Another possible explanation for the apparent over-representation of civil engineers in the complaint and claims populations is that, for whatever reason, incompetence may be more common in this branch of engineering. Both the complaint and pass rate data provide some support for this interpretation. In the complaint population, a higher proportion of civil, structural and geotechnical engineers are charged with incompetence/negligence than is true for electrical or mechanical engineers (70%, 75% and 69% vs. 48% and 28% respectively). Pass rates for civil engineers in California have been significantly lower than the average for the comparison states, while those for mechanical engineering have, with one exception, been within the norm. However, pass rates for electrical engineers have been lower in most years and yet there are only 4 complaints lodged against them. Although it is those who pass these exams and become licensed who are involved in the complaints, the difficulty in passing them may reflect a broader range of topics in civil and electrical engineering. Civil has five depth areas that are covered on the breadth exam. In addition, candidates for licensing in civil engineering must take an additional exam in "special civil" the following day. This lack of specialization in the discipline --

and a regulatory structure that permits this discipline to practice other disciplines as well -- may undermine competence among civil engineers.

That the regulatory structure may be a factor in complaints of incompetence/negligence against civil engineers in California is suggested by the comparison with complaint data in Massachusetts. While the proportion of electrical and mechanical engineers charged with unlicensed activity was similar in the two states (10% and 8% for electrical and 28% and 22% for mechanical in California and Massachusetts respectively), the proportion of civil engineers charged with unlicensed activity was almost four times greater in Massachusetts (12.7% vs. 3.5%). Massachusetts prohibits overlapping practice without prior Board approval between any of its 46 disciplines while California permits one-directional incidental overlap for civil engineers into any discipline and for electrical and mechanical into any discipline except civil engineering. This may help to explain another difference between the two states: while, in Massachusetts, fraud was a more frequent alleged violation in all three practice act disciplines and structural engineering, competence/negligence was more frequent in these disciplines in California.

Another affect of the regulatory structures in Massachusetts and California can be seen in who gets charged with unlicensed activity. While the proportion of *unlicensed engineers* charged with unlicensed activity was virtually identical in these two states (52.1% in California and 51.9% in Massachusetts), *licensed engineers* in Massachusetts -- a state with 46 licensed disciplines and no hierarchical distinctions between them -- were three times as likely to be charged with unlicensed activity as they were in California (14.2% vs. 4.9%).

Complaints against the title act disciplines were rare in both states. In California, the title act disciplines accounted for 17.8% of employed engineers in the state, but only 4.9% of complaints. The title act disciplines and other engineers were also under-represented in the claims population, making up 18.5% of claims, but 36.2% of the nation's employed engineers.

In California, processing time, identifying a violation, and Board actions varied between practice act engineers and the unlicensed. The proportion of open complaints against practice act engineers is almost three times higher than among the unlicensed (13.5% vs. 5.8%). Violations are identified most often among the unlicensed (80%) and persons with multiple licenses in civil and traffic engineering (74%), but in slightly less than half (48%) of the closed cases against practice act engineers. Board action is the most common response when violations are identified against the unlicensed (84%), while referral to the Attorney General occurs most often among those with dual licenses in Civil and Traffic (81%). When violations are identified among practice act engineers, the response is equally split between Board action (40%) and referral to the Attorney General (40%).

Health and Safety

One of the legislatively defined goals for the Title Act Study was to consider how changes to existing laws regulating engineers would affect the public health, safety and welfare. To assess this requires some measure of the degree to which the public health, safety and welfare are affected by the current licensing system. The positive impacts of engineering and its products on quality of life and economic prosperity are not at issue in regulating this profession. Determining relative differences in the potential for harm among engineering branches would be one way to justify licensing distinctions between them. Measuring the potential for harm was the challenge. Errors in the design of buildings, roads, bridges and products are not tracked by any state or federal agency and the resolution of legal avenues of redress are often private (e.g., out-of-court settlements and insurance claims). ISR located two data sources that offered a limited opportunity to assess differential impacts on public health and safety: DCA's data base on complaints against engineers and a power point presentation on insurance claims compiled by DPIC, one of the two largest insurers of engineers in the U.S.

Complaints

In terms of complaints and insurance claims, the title act disciplines appear to pose less of a threat to public health, safety and welfare than civil and structural engineering -- *as measured by these indices*. Mechanical and electrical engineering are even more under-represented than the title act disciplines in the generation of complaints and insurance claims. Therefore, differential impact on public health and safety does not support the current grouping of practice and title act disciplines.

The complaint process serves to protect the public through enforcement actions against engineers and the maintenance of a fair examination system. How well it does this is difficult to judge. California has the lowest complaint rate per 100,000 registered engineers among the four states with comparable information (an average of 126 per 100,000 for California compared with 179 to 337 for New York, North Carolina and Texas). Is this because California engineers are more ethical and competent, or because the complaint process is more cumbersome and not well publicized? Private parties (individual and corporate clients) initiate half of all complaints. The Board is the second largest source of complaints, accounting for 39%.

In general, complaints against the practice act disciplines come from the public while those against the unlicensed are more likely to come from the Board. While the public is primarily responsible for complaints against practice act only disciplines and practice/title combinations when a single traffic engineer generating multiple Board complaints is removed, the Board initiates complaints against the unlicensed (65%). The public and the Board each generate roughly half of all complaints against title act engineers (45% and 40% respectively).

How quickly complaints are resolved and what happens when they are depends upon the complaint subject's discipline. The proportion of open complaints against practice act engineers is almost three times higher than the proportion among the unlicensed (13.5% vs. 5.8%). Violations are identified most often among the unlicensed (80%) and persons with multiple licenses in civil and traffic engineering (74%), but in slightly less than half (48%) of the closed cases against practice act engineers. Board action is the most common response when violations are identified against the unlicensed (84%), while referral to the Attorney General occurs most often among those with dual licenses in civil and traffic (81%). When violations are identified among practice act engineers, the response is equally split between Board action (40%) and referral to the Attorney General (40%).

The violation alleged also influences the outcome of a complaint. The most common closing code when fraud, competence/negligence or contractual issues are charged is that no violation is found (38%, 37% and 33% respectively). In cases of exam subversion and unlicensed activity, Board action is the most common response (91% and 39% respectively). Thus, cases brought by the Board are more likely to result in an enforcement action (66% of the time), while the largest group of complaints -- those brought by the public -- lead more often to a finding of "no violation" (38% of the time).

Complaints in Other States

The discipline profile of complaints in Massachusetts confirms results from California. Complaints in both states are primarily against civil engineers (40.1% in California and 43.4% in Massachusetts) or the unlicensed (49.2% vs. 36.8%). The other practice act disciplines account for most of the remaining complaints in both states: electrical (1% in California vs. 2.8% in Massachusetts), mechanical (2% vs. 8.3%), structural (3.9% vs. 6%) and geotechnical (3.5% in California and none in Massachusetts).
The complaint rates for mechanical, electrical, chemical and industrial engineering were higher in Massachusetts while those for metallurgical or materials and traffic engineering were higher in California.

The overall rate for complaints against licensed engineers was almost 60% higher in California (44 vs. 28), while that for the unlicensed was more than twice as high in California (43 vs. 16 per 100,000). Total complaints were almost exactly twice as high in California as in Massachusetts (87 vs. 44).

The major difference between the two states was in the treatment of the unlicensed. Massachusetts dismissed all but 18% of cases involving the unlicensed while California found that a violation had occurred in 79% of such cases. The higher complaint rates in California, particularly among the unlicensed, and the states' response to cases against the unlicensed, may be related to the states' regulatory structure. California, as a “board” state, vests more control over the licensing and complaint process in the Board, while Massachusetts, as an “agency” state, vests control over complaints in an Office of Investigations that governs all professions. Exercise of the disciplinary and enforcement function both expresses and justifies the California Board's authority.

Claims

When the number and cost of insurance claims among engineering disciplines are compared against their exposure as measured by client fees generated, structural engineers appear to have a more negative impact on the public health and safety. They generate roughly twice the proportion of claims and claim dollars as client fees while civil and electrical engineers generate less. Mechanical engineering and the "other," presumably title act, disciplines are generally neutral, generating claims and claim dollars in rough proportion to their exposure.

Thus, protection of public health and safety does not appear to be a justification for practice vs. title protection. Two of the three practice disciplines (civil and electrical) have less impact in terms of insurance claims than their exposure leads us to expect while the number of claims and claim dollars are proportional for mechanical engineering and the title act disciplines. When claims involvement is compared to the proportion of employed engineers, civil joins structural in being over-represented, but the two other practice act disciplines and the title act disciplines are under-represented. Either way, mechanical and electrical engineering appear to have less impact on public health and safety and more clearly in common with the title acts than civil engineering.